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Wave propagation in metamaterials and effective parameters retrieving

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Abstract (11 pt)

Abstract is summarized in three to four rows extracted from motivation, purpose, experimental/theoretical procedures and results of the author's work. **(10 pt)**

Metamaterials, as a class of artificial materials with extraordinary electromagnetic properties, require reliable methods of their properties determination. The vast majority of researchers and engineers apply the simple S-parameters based method [1]. Its disadvantage is the ambiguity of the determined effective parameters and applicability to thin slabs only. The other methods based, for example, on the eigenfunctions calculations [Menzel], or analytical calculations [Simovski] require advanced skills either in numerical methods and programming or in analytical derivations and maybe considered as handsome for implementation.

We set a goal to develop a method which is unambiguous but at the same time simple and straightforward. We assume that this can be done by observing the wave propagation inside a metamaterial slab thick enough to avoid transient effects. First, we formulated a retrieval method applicable to relatively thick slab when we can neglect the reflection from the rear interface [2]. Then phase and amplitude dependencies versus coordinates (cell number) allow the refractive index retrieving. Getting the input (Bloch) impedance from the reflection on the input interface serves to determine complex wave effective parameters.

Extending the method further we developed the approach to determine both wave and material effective parameters through the Bloch-mode analysis [3]. The idea is to perform the Bloch mode expansion [4] of the field inside the metamaterial slab when it is illuminated with a plane wave incident from vacuum. Then we determine the effective refractive index from the propagation constant of the dominating (fundamental) Bloch mode. The Bloch and wave impedances are determined by definition as the proportionality coefficient between the electric and magnetic fields of the fundamental Bloch mode.

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